A publication of the
National Aeronautics and
Space Administration

Mission Highlights STS-76

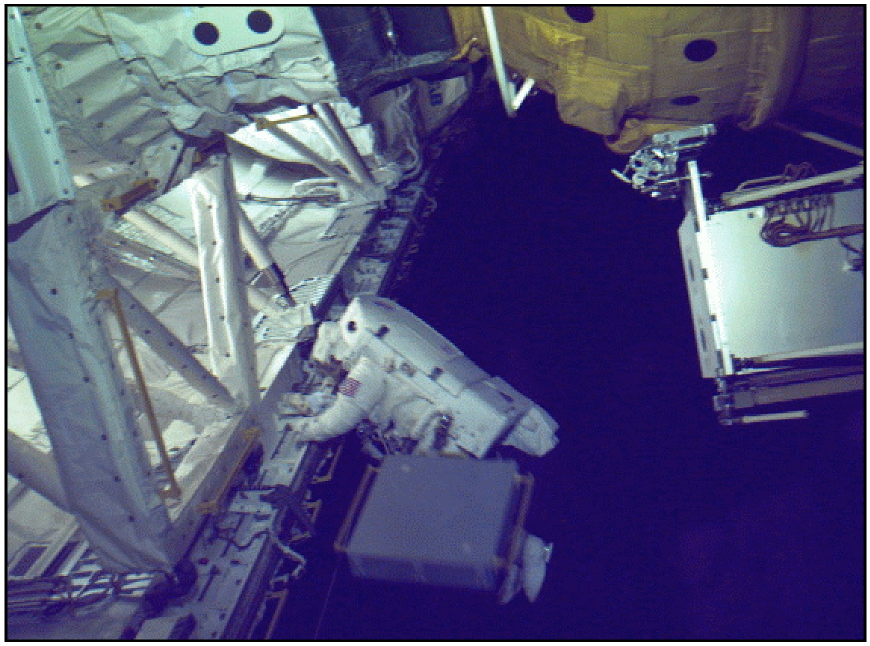
IS-1996-03-001.076JSC
March 1996

Third Mir docking flight marks start of space colonization

The STS-76 mission can be recorded in history books as the first to deliver more than 4,000 pounds of supplies and one American astronaut to the Russian Space Station Mir, and the first to accomplish a space walk while the shuttle and Mir were docked.

"We are beginning the colonization of space here," Commander Kevin Chilton said during a crew news conference. "We have been to and from just as the earlier explorers were to and from North America from Europe and finally they settled and then they started to do productive work and founded this great nation. I kind of look at this in a similar light. We have been coming to and from space and when we get here permanently, then we can start seeing the fruits of our labors."

Before undocking from Mir, Astronauts Linda Godwin and Rich Clifford performed the first space walk during docked operations. The two space walkers began preparing for their six-hour space walk as the hatches were closed between the Russian station and *Atlantis* to pressurize the shuttle for the space walk. Godwin and Clifford floated out of *Atlantis'* airlock at 12:36 a.m. CST March 27, 1996, and made their way to the Mir Environmental Effects Payloads stored in the shuttle's cargo bay. The two attached several experiments to the outside of the Mir station and provided a glimpse of the International Space Station (ISS) era. The space walk, which also tested ISS tools and retrieved a video camera purposely left attached to the docking module, was completed without a hitch.



On the port side of *Atlantis'* cargo bay, Mission Specialist Rich Clifford takes part in the first-ever space walk involving NASA astronauts, while their mother ship was docked with Russia's Mir Space Station.

Space Shuttle *Atlantis*

March 22-31, 1996

Commander: Kevin P. Chilton

Pilot: Richard A. Searfoss

Mission Specialists: Shannon W. Lucid, Linda M. Godwin, Michael "Rich" Clifford, Ronald M. Sega

Astronauts Kevin Chilton and Richard Searfoss work the commander and pilot stations, respectively, for the rendezvous and docking procedures with the Russian Mir Space Station.

STS-76 marked the first U.S. mission to deliver an American astronaut to the Russian space station as Mission Specialist Shannon Lucid became part of the Mir 21 crew. Lucid was to remain on-board Mir until August of 1996.

Payload Commander Ron Sega explained that the doors opened by STS-76 will have far-reaching consequences. "I think our flight will be remembered as an enabling flight, enabling Shannon and the U.S. to do long-duration studies on Mir that will continue and move on into the International Space Station era," Sega said.

Mission Events

Atlantis was launched from the Kennedy Space Center on time at 2:13 a.m. CST Friday, March 22, 1996. Flight controllers noticed a small leak of hydraulic fluid from one of three hydraulic systems aboard the shuttle shortly after liftoff. The hydraulic systems are used only during launch and landing, and the leak from the backup system was observed only while that system was in operation during the climb to orbit. After examination of the leak data, engineers concluded that the leak began as the high pressure hydraulic fluid system pumps were started shortly before launch.

Following a flawless docking at 8:43 p.m. CST, March 23, Mission Specialist Rich Clifford completed safing and pressurizing *Atlantis'* docking vestibule and the hatches were opened between the two spacecraft as *Atlantis'* crew was greeted by Mir 21 Commander Yuri Onufrienko and Flight Engineer Yuri Usachev. Shortly after the hatch opening and initial greetings, the shuttle crew moved into the Mir and Astronaut Shannon Lucid officially became the third member of the Mir-21 crew embarking on a 4 1/2 month stay in space. Official assignment of Lucid to the Mir 21 crew came at 7:30 a.m. CST, March 24.

Transfer and resupply activities on board the joined *Atlantis*/Mir spacecraft continued on Monday as the eight astronauts and cosmonauts worked smoothly through their timeline. Mission Specialist Linda Godwin also continued her work with the European Space Agency Biorack which contained 11 separate scientific investigations.

On March 26, *Atlantis'* astronauts viewed Comet Hyakutake as it continued its close pass by Earth. They told reporters the comet was brilliant and could be seen almost from horizon to horizon.

The hatches between *Atlantis* and Mir were closed March 26 to enable astronauts to depressurize the shuttle's cabin from its standard 14.7 pounds per square inch to 10.2 psi, a standard pre-space walk protocol.

On March 27, 1996, Astronauts Linda Godwin and Rich Clifford successfully completed the first ever space walk from a docked space shuttle. Starting at 12:36 a.m. CST, the two spent 6 hours, 2 minutes and 28 seconds space walking in *Atlantis'* cargo bay and on the exterior of the Mir's docking module. They smoothly performed all of the objectives planned for the space walk, the most important of which was to install the four experiments to monitor the space environment on the exterior of Mir for the next year and a half.

Godwin and Clifford also detached a television camera from the outside of the Mir docking module to return it to Earth, and they evaluated a variety of new space walking tools capable of being used on both U.S. and Russian spacecraft.

Hatches between the shuttle and Mir were closed for the final time at about 7:15 a.m. CST on Thursday, March 28, in preparation for *Atlantis'* undocking at about 7:08 p.m. CST. Prior to the hatch closure, the crews transferred about two tons of scientific equipment, logistical material and resupply items between the two spacecraft.

Atlantis and its five member crew remained in orbit one additional day following the wave-off of two landing opportunities at Kennedy Space Center on March 30. Weather for both landing opportunities was too dynamic to assure flight controllers that it would be acceptable one hour after having to commit to an entry.

Space Shuttle *Atlantis* returned to Earth at 7:29 a.m. CST, March 31, 1996, landing at Edwards Air Force Base, CA. *Atlantis'* descent from orbit occurred on orbit 144 with an engine firing at 6:25 a.m. CST. The main gear touched down at a mission elapsed time of 9 days, 5 hours, 15 minutes and 53 seconds. The STS-76 mission covered approximately 3.8 million miles.

The leak in one of three hydraulic systems caused no difficulty on entry.

Payload Descriptions

The Simplified Aid for EVA Rescue (SAFER) is a small, self-contained, propulsive backpack device that can provide free-flying mobility for a space walker in an emergency. It was designed for self-rescue by a space walker in the event the shuttle is docked to the Mir and thus unable to retrieve a detached, drifting astronaut.

SAFER is attached to the space suit's Portable Life Support System backpack, and is, in essence, a scaled-down, miniature version of the Manned Maneuvering Unit backpack flown aboard shuttle missions in 1984.

Mir Science

Scientific research has always been one of the most important objectives for both the American and Russian space programs, and the long-term research platform supplied by the Mir complex allows extensive studies in fundamental physics, chemistry, human and plant biology and technology, as well as investigations directed toward understanding processes used on Earth. The Mir station was used as a test bed to study several major technology disciplines: structures, materials, biotechnology and physical processes.

Earth sciences research was performed in ocean biochemistry, land surface hydrology, meteorology, and atmospheric physics and chemistry. Observation and documentation of transient natural and human-made phenomena was accomplished with the use of passive microwave radiometers, a visible region spectrometer to study the ocean and a side-looking radar.

Life sciences and fundamental biology applications included investigations that evaluated new technologies for life support systems which enhance the capabilities for on-orbit environmental monitoring. These included characterizing the biological and chemical aspects of the research environment of Mir, and expanding the knowledge of space human factors and extravehicular activity.

ISS risk mitigation consisted of several technology demonstrations associated with human factors and maintenance of crew health and safety aboard the space station. By fully evaluating the Mir interior and exterior environments, such as audible noise levels, radio frequency interference, crew-induced forces to structures, particle impacts on the station and docking configuration stability, information was gathered for the improved design of the ISS.

Microgravity research has the general goal of advancing scientific understanding and providing value on Earth through research in biotechnology, fluid physics, combustion and materials science. The ambient acceleration and vibration environment of Mir was studied for benefit to both research and future engineering programs.

Space science research collected interstellar and interplanetary particles in space to further our understanding of the origin and evolution of planetary systems and life on Earth.

SPACEHAB Module

STS-76 began a series of shuttle-Mir missions that carried a SPACEHAB module onboard. Over the course of these missions, SPACEHAB modules will carry a mix of supplies and scientific equipment to and from Mir.

A double rack in the SPACEHAB module was dedicated to some of the Russian logistics, including the gyrodyne and the individual equipment and seat liner (IESL) kit. The gyrodyne was transferred by the crew to and from Mir to replace a used gyrodyne. This instrument is part of the Mir's control system and provides on-orbit control to the station. The replaced gyrodyne was returned to Earth for the Russians to refurbish for possible later use.

The IESL kit was transferred to Mir to be available for use by Shannon Lucid in case of an emergency return to Earth in a Soyuz capsule. Numerous Russian logistics items totaling approximately 1,900 pounds were carried in the SPACEHAB soft stowage system. Items included food and water containers, clothing and sleeping articles, personal hygiene equipment, a current transformer and a Mir supplemental kit.

The SPACEHAB Biorack is a multi-purpose facility designed to enable biological investigations on plants, tissues, cells, bacteria and insects during space flight. Its main purpose was to investigate the effects of microgravity and cosmic radiation, particularly the effects of high-energy (HZE) particles, on the development of these species. Eleven experiments were conducted during the mission: three from the U.S., three from France, three from Germany, one from Switzerland and one from the Netherlands.

Biorack was a combination of nine different payload elements to be performed throughout the mission. High-energy atomic number charged particles (HZE) radiation was studied to explicitly correlate biological responses with naturally occurring particles. Also, the study of potential microgravity modifications of biological responses to radiation were analyzed.

Studies also looked at the effect of microgravity on bone loss by investigating alterations in gene patterns, the effect of microgravity on gravity sensing and response in hematopoietic cells. PKC, which is an important enzyme in intra-cellular signaling pathways, was analyzed under microgravity conditions. The signaling pathways appear to be sensitive to gravity in a number of cell types.

Mir 21 Cosmonaut Researcher Shannon Lucid is surrounded by a large delivery of new supplies for the Russian space station as she floats between the two docked space craft.

Mission Specialist Linda Godwin completes the donning of her extravehicular mobility unit space suit in the airlock of the Earth-orbiting *Atlantis.*

A dosimetry experiment was flown to document the radiation environment inside the Biorack facility and other locations inside the SPACEHAB module and the middeck. The data provided a radiation baseline for Biorack payload elements.

The Life Sciences Laboratory Equipment Refrigerator/Freezer (LSLE R/F) is a vapor compression refrigerator that was carried in the SPACEHAB module. It carried processed samples from the Biorack as well as the Johnson Space Center frozen stowage experiment which included blood, urine and saliva samples from the Mir-21 crew. These samples are being analyzed on Earth for evidence of accelerated kidney stone development and protein metabolism due to microgravity.

Mir Glovebox Stowage (MGBX): The MGBX was carried in soft stowage bags to replenish hardware for the glove box located on Mir. Equipment and experiments carried in the MGBX included the Combustion Experiments Parts Box used with candle flames in the microgravity experiment, the Forced Flow Flamespread Test, the Passive Accelerometer, the Protein Crystal Growth Experiment and the Protein Crystal Growth Thermal Enclosure System Ancillary.

High Temperature Liquid Phase Sintering (LPS): LPS was developed by the University of Alabama at Huntsville's Consortium for Materials Development of Space. The LPS experiment was carried to the Mir space station aboard STS-76 to be returned to Earth for analysis following the planned shuttle-Mir docking mission of STS-79.

The experiment used the Optizon furnace aboard Mir. A variety of metals were bonded together in a series of experiments over a two-week period. By conducting these technology experiments in space, new insights may be gained concerning industrial needs and operations on Earth. The LPS experiments in microgravity provide greater understanding on how metals bond. One area that could benefit from improved metal composites is the tool industry.

Mir Environmental Effects Payload (MEEP): MEEP, managed by NASA's Langley Research Center, Hampton, VA, studied the frequency and effects of space debris striking the Mir space station. MEEP studied both human-made and natural space debris, capturing some debris for later study. It was attached to the Mir shuttle docking module during a space walk by mission specialists Godwin and Clifford.

MEEP also exposed selected and proposed ISS materials to the effects of space and orbital debris. Because the ISS will be placed in approximately the same Earth orbit as Mir, flying MEEP aboard Mir will give researchers an opportunity to test materials for the ISS in a comparable orbital position.

MEEP consisted of four separate experiments. The Polished Plate Micrometeoroid and Debris experiment was designed to study how often space debris hits the station, the sizes of the debris, the source of the debris and the damage the debris would do if it hit the station. The Orbital Debris Collector experiment was designed to capture orbital debris and return them to Earth to determine what the debris are made of and their possible origins.

The Passive Optical Sample Assembly I and II experiments consisted of various materials that were intended for use on the ISS. These materials included paint samples, glass coatings, multi-layer insulation and a variety of metallic samples.

MEEP data was studied to determine what kind of debris hits the space station and how those contaminants can actually collect on some surfaces, affecting long-term performance.

KidSat: KidSat enabled students to configure their own payload for flight on the shuttle. The students then commanded a digital camera from their classrooms, and downloaded images of Earth in near real-time. Images were used as the basis for a variety of classroom discoveries including history, geography, geology, physics, oceanography, mathematics and current events, and as a means of exploring their own planet using NASA data.

The KidSat concept was inspired by a group of high school students working on a shuttle mission as part of the Jet Propulsion Laboratory's (JPL) collaboration with The Johns Hopkins University Institute for Academic Advancement of Youth (IAAY). The program was developed by JPL, IAAY and the University of California, San Diego (UCSD). Significant support from the Johnson Space Center also was a key element of this project, and the first digital still camera is a Kodak DC460C. The project is supported by NASA's Office of Human Resources and Education, Washington, DC, with support from NASA's Office of Mission to Planet Earth, Office of Space Flight and the Office of Space Science, Washington, DC.

Shuttle Amateur Radio Experiment (SAREX): Ground-based amateur radio operators ("hams") had the opportunity to contact shuttle astronauts through a direct voice ham radio link. The amateur radio station at the Goddard Space Flight Center, Greenbelt, MD, operated around the clock during the mission, providing SAREX information and retransmitting live shuttle air-to-ground audio.

Trapped Ions in Space (TRIS): The Naval Research Laboratory's (NRL's) TRIS experiment measured a recently discovered belt of energetic cosmic ray nuclei trapped in Earth's magnetic field to quantify radiation hazards in space and lead to a better theoretical understanding of how these cosmic ray nuclei have become trapped in the Earth's magnetic field.

So-called "anomalous cosmic rays," which originate in the nearby interstellar medium, form the radiation belt that TRIS observed. These trapped anomalous cosmic rays have sufficient energy to pose a potential radiation hazard to some lightly shielded electronic systems planned for the ISS and perhaps to astronauts during space walks in certain parts of the orbit. TRIS was built by NRL's Space Science Division. The flight was sponsored by the U.S. Air Force Space Test Program office at the Johnson Space Center.

CREW BIOGRAPHIES

Commander: Kevin Chilton (Col., USAF). Chilton, 41, was born in Los Angeles, CA. He received a bachelor of science degree in engineering science from the U.S. Air Force Academy and a master of science degree in mechanical engineering from Columbia University on a Guggenheim Fellowship. He became an astronaut in 1988 and served as pilot on his first two shuttle flights, STS-49 in 1992 and STS-59 in 1994. With the completion of STS-76, Chilton had logged more than 704 hours in space.

Pilot: Richard Searfoss (Lt. Col., USAF). Searfoss, 39, was born in Mount Clemens, MI, but considers Portsmouth, NH, to be his hometown. He received a bachelor of science degree in aeronautical engineering from the USAF Academy and a master of science degree in aeronautics from the California Institute of Technology on a National Science Foundation Fellowship. Searfoss was selected to join the astronaut corps in 1990 and served as pilot on his first shuttle flight, STS-58 in 1993. With the completion of STS-76, Searfoss had logged more than 557 hours in space.

Mission Specialist: Ronald Sega (Ph.D.). Sega, 43, was born in Cleveland, OH, but considers Northfield, OH, and Colorado Springs, CO, to be his hometowns. He received a bachelor of science degree in mathematics and physics from the U.S. Air Force Academy, a master of science degree in physics from Ohio State and a doctorate in electrical engineering from the University of Colorado. Sega became an astronaut in 1991 and served as a mission specialist on his first space flight, STS-60, in 1994.

With the completion of STS-76, Sega had logged more than 420 hours in space.

Mission Specialist: Rich Clifford (Lt. Col., USA, Ret.). Clifford, 43, was born in San Bernardino, CA, but considers Ogden, UT, to be his hometown. He received a bachelor of science degree from the United States Military Academy, West Point, NY, and a master of science degree in aerospace engineering from the Georgia Institute of Technology.

Clifford was selected as an astronaut in 1990 and has flown as a mission specialist on two previous shuttle flights, STS-53 in November 1992 and STS-59 in April 1994. With the completion of STS-76, Clifford had logged more than 665 hours in space, and more than 6 hours of space walk time.

Mission Specialist: Linda Godwin (Ph.D.). Godwin, 43, was born in Cape Girardeau, MO, but considers Jackson, MO, to be her hometown. She received a bachelor of science degree in mathematics and physics from Southeast Missouri State and a master of science degree and a doctorate in physics from the University of Missouri. Godwin began working at NASA in 1980 and became an astronaut six years later. She has flown in space twice, on STS-37 in April 1991 and STS-59 in April 1994. With the completion of STS-76, Godwin had logged more than 634 hours in space, and more than 6 hours of space walk time.

Inflight portrait in the base block module of Russia's Mir Space Station. Bottom row (l to r) Yuri Usachev, Yuri Onufrienko and Shannon Lucid. Back row (l to r) Ron Sega, Linda Godwin, Kevin Chilton and Richard Clifford. Not pictured is Rick Searfoss.

STS-76 Quick Look

Launch Date: March 22, 1996
Time: 2:13 a.m. CST
Site: KSC Pad 39B

Orbiter: *Atlantis*
OV-105-16th flight
Orbit: 160 naut. Miles
213 nm for docking
Inclination: 51.6 degrees

Mission Duration: 9 days, 5 hrs,
Landing Date: Mar. 31, 1996
Time: 7:29 a.m. CST
Site: Edwards AFB

Crew: Kevin Chilton (CDR)
Richard Searfoss (PLT)
Ronald Sega (MS1)
Rich Clifford (MS2)
Linda Godwin (MS3)
Shannon Lucid (MS4)

Mir 21 Yuri Onufrienko (CMDR)
Crew: Yuri Usachev (Flght Eng)

Cargo Bay Payloads: SPACEHAB
Orbiter Docking Sys.
MEEP

In-Cabin Payloads: KidSat
SAREX

Mission Specialist: Shannon Lucid (Ph.D.). Lucid, 53, was born in Shanghai, China, but considers Bethany, OK, to be her hometown. She received a bachelor of science degree in chemistry from the University of Oklahoma and a master of science and doctor of philosophy degrees in biochemistry from the University of Oklahoma.

Lucid was selected as an astronaut in 1978 and has served as a mission specialist on four previous shuttle flights, STS-51B in 1985, STS-34 in 1989, STS-43 in 1991 and STS-58 in 1993. At the conclusion of shuttle-Mir joint-docked operations, Lucid remained aboard Mir serving as a station researcher. She is to return to Earth when Atlantis again docks to Mir during mission STS-79 in August 1996. With the completion of STS-76, Lucid had logged more than 1,059 hours in space. She remained aboard Mir, and her space hours continue to accumulate.

MIR-21 CREW

Commander: Yuri Onufrienko. Onufrienko, 35, was born in the village of Ryasnoye, Zolochevsk district, Kharlov region, Russia. He graduated from the V.M. Komarov Eisk Higher Military Aviation School for Pilots with a pilot-engineer's diploma and was assigned to the Gagarin Cosmonaut Training Center. He attended the general space training course, and trained for space flight as part of the test-cosmonaut group in the Mir orbital station program and backup crew commander for Mir-18 and Mir-Shuttle programs. In addition, he trained for flight on the Mir station for Mir-19 and Mir-shuttle programs as the commander of the backup crew, space flight in the Soyuz-TM transport vehicle and Mir station as commander of the main crew for Mir-21. Onufrienko, along with Mir-21 Flight Engineer Yuri Usachev, were launched aboard a Soyuz-TM transport vehicle on the start of the Mir-21 mission on February 21, 1996. Onufrienko and Usachev docked to the Mir station two days later. The Mir-21 mission is Onufrienko's first space flight mission.

Flight Engineer: Yuri Usachev. Usachev, 38, was born in the city of Donetsk, Rostov Region, Russia. He graduated from the Moscow Aviation Institute and since then has worked at the RSC Energia. He attended the general space training course at the Gagarin Cosmonaut Training Center and trained for space flights as a member of the test-cosmonaut group in the Mir station program, flight on the Mir complex in the Mir-13 program as flight engineer of the backup crew, flight on the Mir complex in the programs Mir-14 and Altaire (France) as flight engineer of the backup crew and trained in the Mir-15 program as flight engineer of the main crew. From January to July 1994 he flew on the Mir complex for 182 days. He next trained for flight on the Mir station as flight engineer of the backup crew in the Mir-19 and Mir-Shuttle programs and space flight in the Soyuz-TM transport vehicle and Mir station as flight engineer of the main crew for Mir-21. Usachev, along with Mir-21 Commander Yuri Onufrienko, was launched aboard a Soyuz-TM transport vehicle on the start of the Mir-21 mission on February 21, 1996. They docked to the Mir station two days later. The Mir-21 mission is Usachev's second space flight mission.

The crew patch depicts the Space Shuttle *Atlantis* and the Russian Space Station Mir as the two space ships prepare for a rendezvous and docking. The "Spirit of 76," an era of new beginnings, is represented by the space shuttle rising through the circle of 13 stars in the Betsy Ross flag. STS-76 begins a new period of international cooperation in space exploration with the first shuttle transport of a U.S. astronaut, Shannon Lucid, to Mir for extended joint space research. Frontiers for future exploration are represented by the stars and planets. The three gold trails and the ring of stars in the union form the astronaut logo. Two suited extravehicular activity (EVA) crew members in the outer ring represent the first EVA during Shuttle-Mir docked operations. The EVA objectives are to install science experiments on the Mir exterior and to develop procedures for future EVA's on the ISS.

Pic 1: S76e5206-On the port side of *Atlantis'* cargo bay, Mission Specialist Rich Clifford takes part in the first-ever space walk involving NASA astronauts while their mother ship was docked with Russia's Mir Space Station.

Pic 2: S76e5138- Astronauts Kevin Chilton and Richard Searfoss man the commander and pilot stations, respectively, for the rendezvous and docking procedures with the Russian Mir space station.

Pic 3: S76e5229- Mir 21 Cosmonaut Researcher Shannon Lucid is surrounded by a large delivery of new supplies for the Russian space station as she floats between the two docked space craft.

Pic 4: S76e5205-Mission Specialist Linda Godwin completes the donning of her extravehicular mobility unit space suite in the airlock of the Earth-orbiting *Atlantis.*

Pic 5: S76e5198- Inflight portrait in the base block module of Russia's Mir space station. Bottom row (l to r) Yuri Usachev, Yuri Onufrienko and Shannon Lucid. Back row (l to r) Ron Sega, Linda Godwin, Kevin Chilton and Richard Clifford. Not pictured is Rick Searfoss.